GRID CONTROL CENTRE

South of Scotland Electricity Board

Grid Control Centre

Strathkelvin House, the grid control centre of the South of Scotland Electricity Board (SSEB), was commissioned in the spring of 1972. The centre, which is located on the outskirts of Glasgow, controls the entire power system in the south of Scotland. Operations are carried out in conjunction with the North of Scotland Hydro-Electric Board's (NSHEB) control centre at Pitlochry to agree on the most economical work schedule for all Scottish plant — which power stations to run, when to run them, and at what output — and the degree of transmission circuit switching permissible within the established standards of security of power supply.

Power supply

In Britain there are three authorities responsible for the generation and transmission of electricity — SSEB for the south of Scotland, NSHEB for the north of Scotland and the Central Electricity Generating Board (CEGB) for England and Wales. The power stations of all three authorities feed into the national grid, but each authority controls the power stations and grid transmission lines in their own area. The two Scottish boards plan and operate their systems jointly to minimise the total cost for Scotland. Transmission interconnections across the border to the CEGB enable either side to help the other in times of difficulty and permit two-way trading with optimum profit to both sides.

Power stations

The map overleaf shows SSEB power stations with distinctive symbols indicating the different types. There are large differences in the amounts of electricity which the power stations produce and the ways in which they produce it. Longannet, the largest power station in Scotland, is coal-fired with a capacity of 2400 megawatts — enough to supply all the south of Scotland on a spring day; Stonebyres, at the other end of the scale, is hydro-powered and produces only five megawatts.

Coal-fired stations provide over 60 per cent of the output and the remainder is produced mainly by nuclear power stations with smaller contributions from oil, hydro electric and gas-turbine stations. Start-up time from cold for large nuclear and conventional stations is measured in hours, but for hydro-power and gas turbines it is usually only a matter of minutes.

National grid

Covering the whole of Britain, the national grid is among the largest fully interconnected transmission systems in the world. SSEB's high voltage grid network (see map overleaf) is part of this system. Grid switching stations are sited at each power station and at other key points throughout the system.

The operations of the grid control centre are designed to:

(1) Co-ordinate and monitor the switching of power lines in the event of any part of the grid network being damaged, in compliance with safety regulations.
(2) Maintain the security of the grid system.
(3) Control generating plant so that total output matches consumers' demands at the lowest overall cost.

The control centre monitors the transmission of electricity to various bulk supply points throughout the country. From these supply points electricity is carried at lower voltages within the distribution network, control of which is the responsibility of the Board's three distribution control centres in Edinburgh, Glasgow and Hamilton. The grid control centre and the distribution control centres work in close harmony to ensure high security of consumer supplies. The total control system is designed to keep costs to a minimum consistent with high standards of supply.

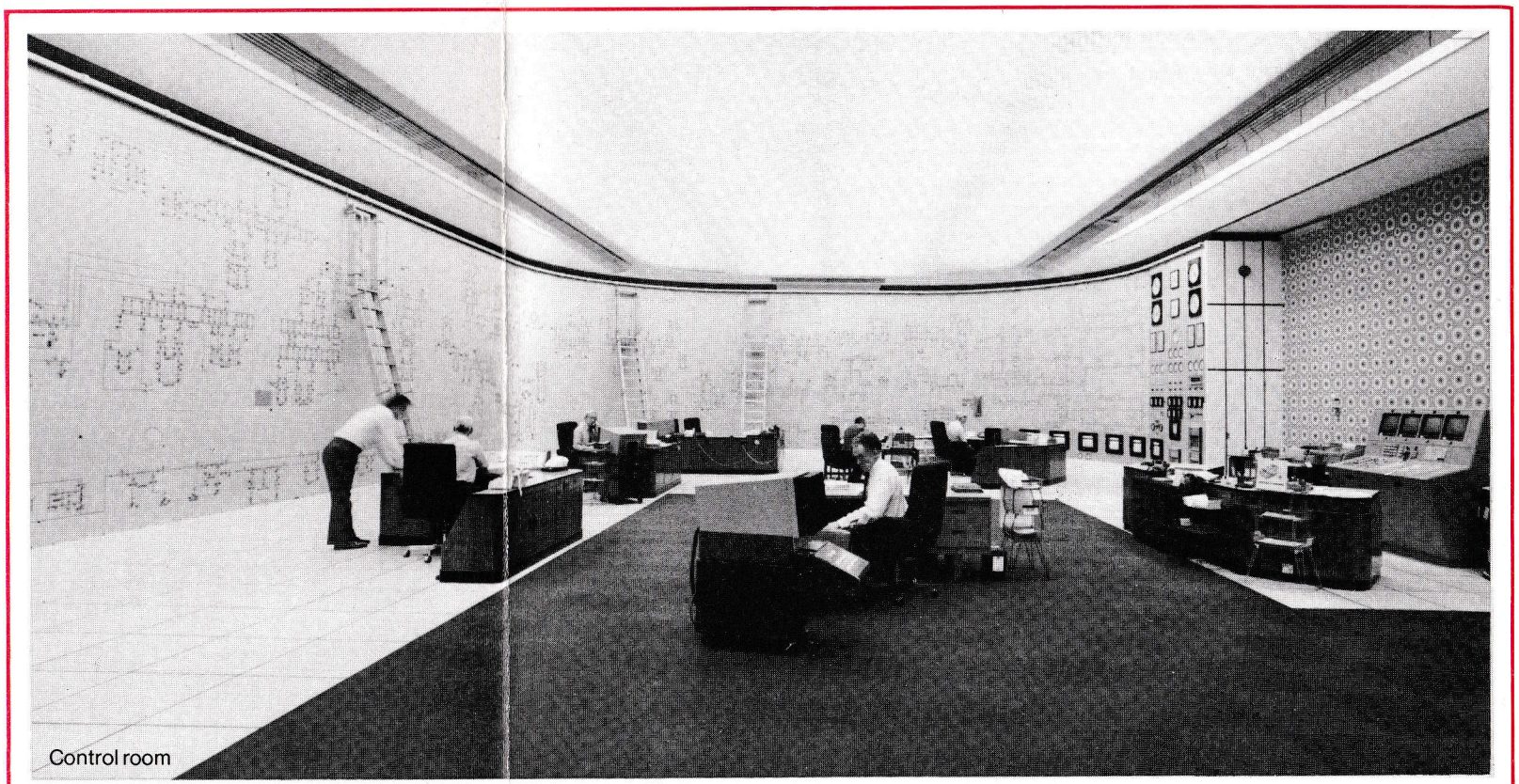
Forecasting the demand

Demand for electricity in the south of Scotland may vary from a few hundred megawatts on a summer's night to six or seven times as much on a winter's evening. Indeed in winter a difference of one degree in temperature can produce a variation in demand equivalent to 100,000 horsepower in the south of Scotland alone.

In making their forecast of demand, the grid control centre staff must take into account not only the established pattern of seasonal, weekly and daily variation, but also the effect of more elusive factors such as fluctuating weather, public holidays, or perhaps a popular television programme, at the end of which cookers and kettles are simultaneously switched on in many thousands of homes.

The forecast of the demand is continually reviewed. This can involve planning for weeks ahead or deciding in a matter of hours and minutes how best to deploy the power stations and arrange grid power lines to meet requirements. The bar chart shows how this works during a typical 24-hour period. The height of the panel above each clockface represents the power being consumed at about that time. Sub-divisions within each panel show what proportion of the total is contributed by each type of station.

A merit order of power stations is established, whereby the lowest cost-of-production plant makes the most sustained contribution. Thus, the nuclear stations, because their running costs are low, are never shut down; and the lowest-cost conventional steam stations are run as nearly as possible for 24 hours a day, year in, year out. Steam stations with higher costs of



Control room

production generate during the day and close down at night and weekends. Hydro-electric stations make use of natural water resources whenever they are available and economical. In conjunction with NSHEB it is planned to conserve hydro power when generation costs are low and to maximise its use when these costs are high. At NSHEB pumped storage plant, water is pumped to a higher reservoir by electricity from low cost Scottish thermal power stations at times of low demand, and hence low fuel costs, and returned to a lower reservoir to generate electricity at times of high demand when fuel costs for direct generation would be higher. Gas turbines are called in only at times of heavy demand or emergency.

The Board's computer at headquarters is used via a data-link several times a day to assist in optimising the minimum cost operation for the whole of Scotland. This provides a basis for system operation, but in practice continual adjustments are required to cater for unpredictable variations. The computer is also used to investigate any overloading on the transmission system following faults.

Control room

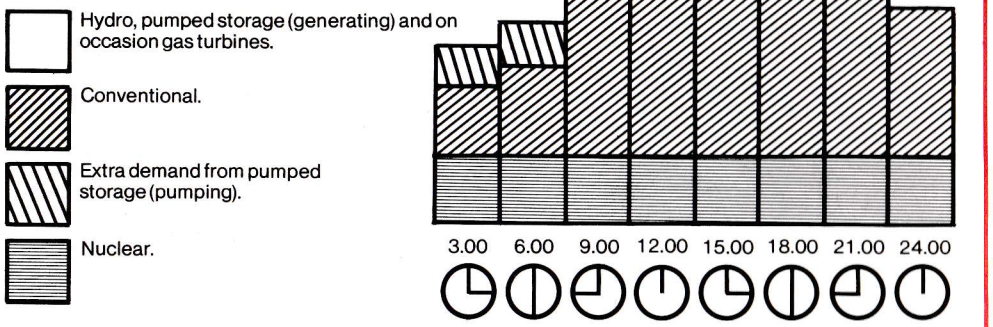
The control room is manned 24 hours a day, in eight-hour shifts. The room is air-conditioned, sound-insulated and fitted with glare-free illumination of infinitely adjustable brilliancy. In front of a large diagram of the grid, which occupies more than half the wall space, are desks for the control staff. The senior grid control engineer, who is in overall charge of the shift, sits in the centre of the room. On his right is the production team, on the left the system team; their duties are described below. To assist them with statistical work a shift clerk completes the team. A visual display unit is used by the control room staff to communicate with the Board's main computer which helps engineers to:

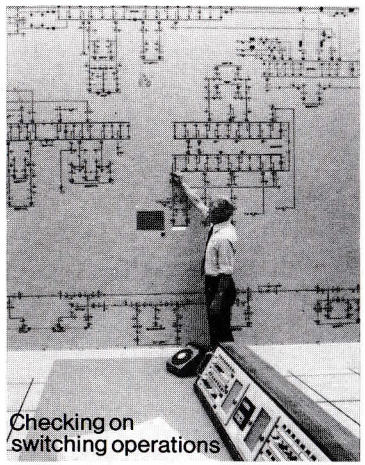
(1) Check the security of the Board's transmission system prior to transmission line outages.
(2) Determine the consequences of faults which might occur.
(3) Study the economics of the proposed operations of power stations.

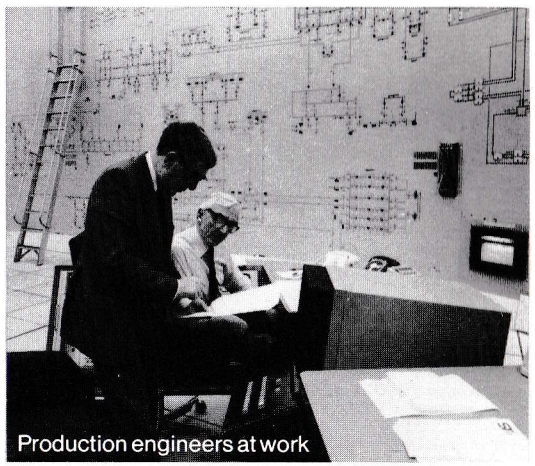
The production engineer's desk has radio and telephone handsets, both with push-button control, to provide communication with power stations, grid switching stations, other control centres and key transmission maintenance centres. To reduce the noise level, a quiet-speaker intercom system is used for conversation within the control room and with senior staff elsewhere in the building.

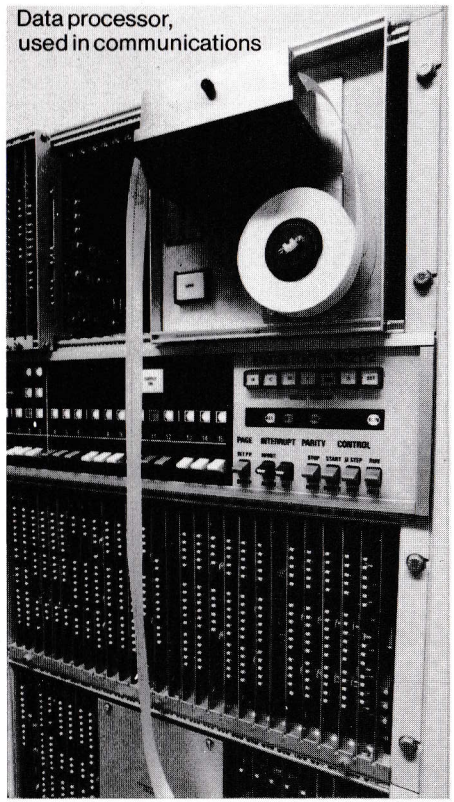
Associated with each desk is a cathode ray tube unit on which is displayed, on request, data from power stations and power-line load-flow information. The display is not televised in the popular sense; it is formed directly from incoming telemetry (measurements received from a distance in coded form, subsequently decoded and displayed in conventional form). Similar equipment is installed at each of the three desks.

How the varying demand for electricity is met. The panel above each clock face shows the contribution by different types of power station.




Checking on switching operations


Production engineers at work


Data processor, used in communications

Production team

The production team face the wall panel of meters and chart recorders which indicate and record the state of supply and demand. Their job is to compare the actual situation with the planned programme and to give power stations instructions to correct variations from the planned programme. The work includes all operational aspects of scheduling power station operations to match requirements of Scottish consumers. Spare conventional steam generating plant is kept in readiness to start up. If possible, other plant capable of running at very short notice (hydro, pumped storage or gas turbine) is kept in reserve and for these stations there is a special display console and telegraph system.

An important duty of the production team is to arrange interchanges of power with CEGB and NSHEB. SSEB (for the Scottish boards) and CEGB buy surplus power at agreed prices, and the arrangements are reviewed every few hours. The profits and savings from these exchanges help to reduce the cost of electricity to consumers on both sides of the border.

System team

The system engineer and his team co-ordinate all transmission activity to ensure a viable and secure SSEB grid system for power supply to bulk distribution or interchange points. The system engineer is also responsible for authorising work on the grid and for ensuring that transmission plant such as circuit breakers, transformers and overhead lines, on which men are working, are switched out and made safe in accordance with SSEB safety rules.

The work involves constant use of the grid wall diagrams. So that it can be easily amended, the diagram is built up in a mosaic of over 180,000 detachable plastic tiles. In addition to the painted lines and symbols on the diagram, there are model switches which are set to show the condition of the actual switches on the grid. Some of these models incorporate lamps which indicate when a switch has opened or closed by showing a discrepancy between the state of the model and that of the switch itself. The system team therefore have a complete picture at all times showing if each switch on the system is open or closed.

Communications

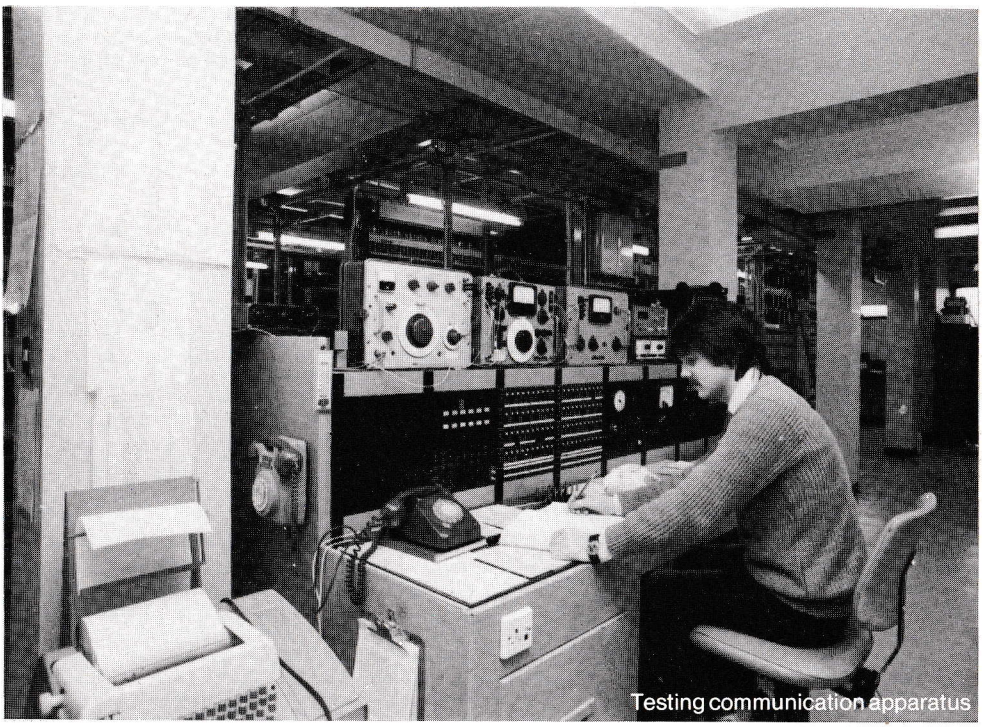
One of the essential requirements of a grid control centre is security of communications. The site of the centre was carefully chosen in order to obtain maximum diversity of communication circuits and security of power supplies.

The major part of the Board's communications is provided by rented Post Office circuits but these are backed up by the Board's private pilot cable network and by microwave radio links. In the event of failure or non-availability of land lines, radio contact is also available to all major power stations and to transmission staff in the field.

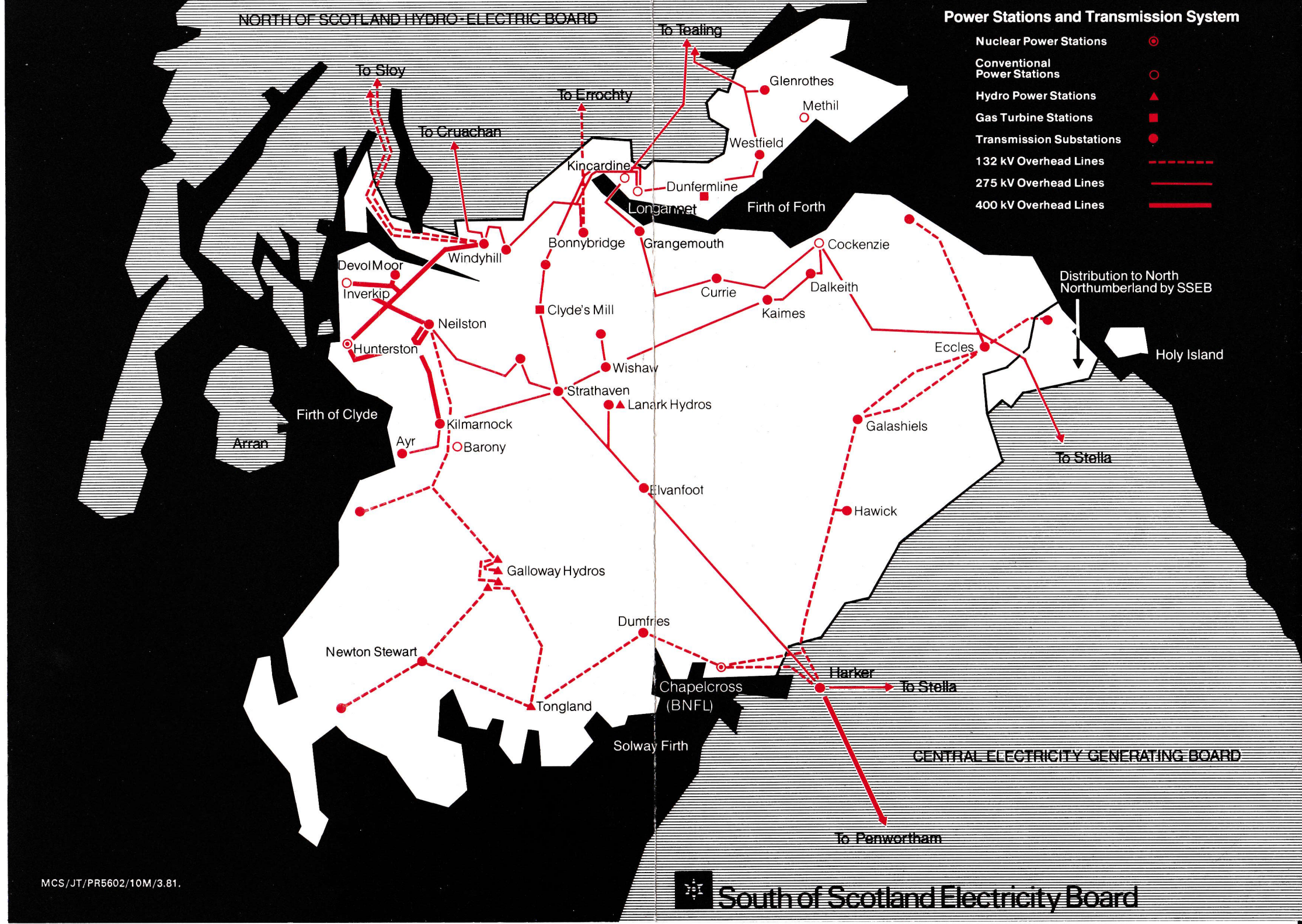
Each telephone line from the building carries not only a telephone conversation, but also up to ten above-speech signalling channels. The latter are used for telemetering, signalling of circuit breaker and alarm conditions, telephone calling, telegraph instructor and teleprinter signalling, etc. (Used in this way, fewer than 40 lines are needed to carry the communication traffic of the centre.)

The telemetry system conveys measurements of the outputs of power stations, power flows on the grid lines, system voltage and frequency from outlying points in the network. Each reading to be transmitted is converted into a series of pulses with a repetition rate proportional to the size of the reading. By means of multiplex units up to 15 of these readings can be transmitted over one signalling channel. In this way some 500 telemetered quantities are conveyed to the control centre. The outputs from the multiplex decoders are each connected to telemeters which give a direct current output, proportional to the impulse rate, to drive the display instruments in the control room.

A data processor scans the outputs of all the telemeters, converts them into digital form, adjusts the scaling and finally generates the alpha-numeric information to 'write' the required letters and numbers on the cathode ray displays in the control room. The telemetering system described above, along with the tele-indication system, has been in use for many years. Studies are now well advanced on modern digital equipment with a much faster response time capable of higher telemetering accuracy, which will be used to replace the existing equipment at the appropriate time.



Testing communication apparatus


NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD
Power Stations and Transmission System
Nuclear Power Stations
Conventional Power Stations
Hydro Power Stations
Gas Turbine Stations
Transmission Substations
132 kV Overhead Lines
275 kV Overhead Lines
400 kV Overhead Lines
To Tealing
To Sloy
To Errochty
To Cruachan
Glenrothes
Methil
Westfield
Kincardine
Dunfermline
Longannet
Firth of Forth
Bonnybridge
Grangemouth
Cockenzie
Windyhill
Devol Moor
Inverkip
Currie
Dalkeith
Kaimes
Clyde's Mill
Neilston
Hunterston
Distribution to North Northumberland by SSEB
Holy Island
Eccles
Wishaw
Strathaven
Lanark Hydros
Firth of Clyde
Kilmarnock
Arran
Ayr
Barony
Galashiels
To Stella
Elvanfoot
Hawick
Galloway Hydros
Dumfries
Newton Stewart
Harker
To Stella
Chapelcross (BNFL)
Tongland
Solway Firth
CENTRAL ELECTRICITY GENERATING BOARD
To Penwortham
MCS/JT/PR5602/10M/3.81.
South of Scotland Electricity Board